use Euler's title, an 'Introductio in Analysin Infinitorum.' A practice has sprung up of late (encouraged by demands for premature knowledge in certain examinations) of hurrying young students into the manipulation of the machinery of the differential and integral calculus before they have grasped the preliminary notions of a *limit* and of an *infinite series*, on which all the meaning and all the uses of the infinitesimal calculus are based. Besides being to a large extent an educational sham, this course is a sin against the spirit of mathematical progress. The methods of the differential and integral calculus, which were once an outwork in the progress of pure mathematics, threatened for a time to become its grave. Mathematicians had fallen into a habit of covering their inability to solve many particular problems by a vague wave of the hand towards some generality, like Taylor's theorem, which was supposed to give 'an account of all such things,' subject only to the awkwardness of practical inapplicability. Much has happened to remove this danger and to reduce d/dx and $\int dx$ to their proper place as servants of the pure mathematician. . . . For the proper understanding of this important branch of modern mathematics [*i.e.* function-theory], a firm grasp of the doctrine of limits and of the convergence and continuity of an infinite series is of much greater moment than familiarity with the symbols in which these ideas may be clothed. It is hoped that the chapters on inequalities, limits, and convergence of series [chapters xxiv.–xxvi.], will help to give the student all that is required both for entering on the study of the theory of functions and for rapidly acquiring intelligent command of the infinitesimal calculus. In the chapters in question, I have avoided trenching on the ground already occupied by standard treatises: the subjects taken up, although they are all important, are either not treated at all or else treated very perfunctorily in other English text-books."

No student who masters the present treatise will pass such judgment upon these chapters, or, indeed, upon any part of the work. What the writer aims at, and succeeds in achieving, is thoroughness.

The first part occupied twenty-two chapters; the second part occupies chapters xxiii.–xxxvi.

Following on the lines of our previous notice (*l.c.*), we give a brief analysis of the chapters:—23, permutations and combinations (with applications to binomial and multinomial theorems, distributions and derangements, and the theory of substitutions); 24–26, see extract above; 27, binomial and multinomial theorems for any index: 28, exponential and logarithmic series (with an account, and applications, of Bernoulli's numbers); 29, 30, summation of the fundamental power-series for complex values of the variable, and general theorems regarding the expansion of functions in infinite forms—these are two splendid chapters, which the author says

"may be regarded as an elementary illustration of the application of the modern theory of functions. They are intended to pave the way for the study of the recent works of Continental mathematicians on the same subject. Incidentally, they contain all that is usually given in English works under the title of analytical trigonometry. If anyone should be scandalized at this traversing of the boundaries of English examination subjects, I must ask him to recollect that the boundaries in question were never traced in accordance with the principles of modern science, and sometimes break the canon of common-sense. . . . The timid way, oscillating between ill-founded trust and unreasonable fear, in which functions of a complex variable have been treated in some manuals, is a little discreditable to our intellectual culture. Some expounders of the theory of the exponential function of an imaginary argument, seem even to have forgotten the obvious truism that one can prove no property of a function which has not been defined."

Chapter 30, moreover, closes with "a careful discussion of the reversion of series and of the expansion in power-series of an algebraic function—subjects which have never been fully treated before in an English text-book, although we have in Frost's *curve-tracing* an admirable collection of examples of their use" (this is a work often referred to with high commendation in the text). To resume our analysis, chapter 31 is on the summation and transformation of series in general; 32–34 gives a thorough discussion of continued fractions and their applications; 35 gives numerous general properties of integral numbers; and 36 is on probability, or the theory of averages. In this last chapter the author has "omitted certain matter of doubtful soundness and of questionable utility; and filled its place by what I hope will prove a useful exposition of the principles of actuarial calculation."

The student of the present day knows that "things are not always what they seem," so when he hears that an elementary text-book of algebra occupies more than a thousand octavo printed pages, he is prepared to find that the "elementary" is comparative, and the "algebra" comprises some other subjects, in ordinary parlance, called by other names. He will find the present work most readable, provided he comes to the perusal with the requisite knowledge and ability, and when he has got to the end of the course he will have an excellent foundation for all his after mathematical reading. Prof. Chrystal gives good advice, which we copy. "When you come on a hard or dreary passage, pass it over; and come back to it after you have seen its importance or found the need for it further on. To facilitate this skimming process, I have given, after the table of contents, a suggestion for the course of a first reading." There are numerous "historical notes," which form a conspicuous and useful feature of the whole work.

The author uses the expression (see above) "dreary passage": we have not come across these, but we can certify with regard to the first part, that we have taken it up again and again, and have always found it difficult to rest contented with a brief glance, and the part before us appears, in some respects, to be even more attractive.

FERMENTATION WITH PURE YEAST.

The Micro-organisms of Fermentation, practically considered. By Alfred Jörgensen. Edited from the German by G. Harris Morris, Ph.D., F.C.S., F.I.C., &c. With an Introduction by Horace T. Brown, F.C.S., F.I.C. (London: F. W. Lyon, 1889.)

DURING the past ten years in which the investigation of micro-organisms and their functions has been so actively pursued there has been a conspicuous absence of any work dealing with the progress made in our knowledge of those particular forms which are of industrial importance. Thus whilst numerous text-books in various languages have appeared embodying the latest discoveries in the relationship of micro-organisms to disease, the only noteworthy treatise on the technological side of

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bacteriology since Pasteur's "Etudes sur le Vin, le Vinaigre, et la Bière," the last of which was published in 1876, is Alfred Jörgensen's "Micro-organismen der Gährungsindustrie" (1886), of which the volume before us is an edited translation. This lack of text-books is doubtless in great measure due to the industrial aspects of micro-organisms having been comparatively neglected during the time that Pasteur, Koch, and their numerous disciples have been busily engaged in the investigation of questions of still more absorbing human interest. But whilst the great majority of bacteriologists have during this past decade been thus occupied in establishing or endeavouring to establish the connection between numerous diseases and specific organisms, a few more silent workers have been patiently engaged upon the less sensational though no less arduous task of placing the fermentation industries on a more scientific basis, adding in fact to the structure which had been commenced by Pasteur in his "Etudes" referred to above. The foremost in this field of research has unquestionably been Christian Hansen of the now world-famed Carlsberg Laboratory near Copenhagen, and to a concise and most lucid description of whose successful labours the present volume is chiefly devoted. The principal addition which has been made to our knowledge of the fermentation organisms by Hansen has been the precise characterization of a number of different "races" of yeast and the determination of the specific features of the fermentation induced by each particular race. Thus whilst Pasteur attributed the various diseases in wine and beer to the presence of organisms other than yeast, Hansen has shown that certain races of yeast itself are capable of bringing about most serious disturbances in the fermentation process. The lines on which Hansen has differentiated these several races of yeast, and the methods by which their pure culture may be effected are clearly though briefly described in this work, with which latest developments of brewing technology, both the author and translator have already identified themselves in the past.

The influence which has been exerted by the researches of Pasteur and Hansen on the practical conduct of the fermentation industries is quite analogous to that which has resulted in surgery from the investigations of Lister and Koch, in both cases the principle of rigid scientific cleanliness has become the order of the day. Thus we read, "the air in the fermenting-room may contain a world of germs which, in the fermentation industries, bring with them the most calamitous results; it is, however, possible to obtain air free from these invisible germs, and it admits of no doubt that, on the one hand, the purification of the air in the fermenting-room by passing it through a salt-water bath, and, on the other hand, the most rigidly executed order and cleanliness in the cellars of the Old Carlsberg brewery, stand in direct relation to the results."

From a practical point of view, the chief merit due to Hansen is that he has not only shown how pure growths of yeast may be obtained in the laboratory, but that he has further devised methods by which these pure cultures may actually be employed on the largest brewery scale. This brewing with pure yeast has already assumed very large dimensions on the Continent where a continually increasing number of breweries receive regular supplies of pure material. We have ourselves visited the laboratories of the Wissenschaftliche Stationen für Brauerei und Brennerei at Berlin and at Munich, and can testify to the impressiveness of witnessing the careful preparation on the manufacturing scale of different forms of pure yeast, each possessed of specific fermenting properties, which are then transmitted to various parts of Europe according to the special requirements of different breweries. These experimental brewing-stations, like so many other similar institutions on the Continent, are directly or indirectly subsidized by the State and number amongst their staff men of universal reputation in their particular departments. As we should anticipate, this method of scientific brewing with pure yeast has so far taken no root in this country, although we are glad to know that the translator, along with Mr. Horace Brown, has for some time past been engaged upon its experimental trial, and we learn from the latter in his introduction to this book "that, in a more or less modified form, pure yeast culture will play a very important part in the brewing of the future in this country."

This little work, which is condensed into 166 pages, and profusely illustrated and provided with an admirable bibliography, should receive the most careful attention from practical men, for whom it is mainly intended. Even the purely scientific student will find much in its pages that should prove of service to him.

PERCY F. FRANKLAND.

OUR BOOK SHELF.

An Epitome of the Synthetic Philosophy. By F. Howard Collins, with a Preface by Herbert Spencer. (London Williams and Norgate, 1889.)

THE aim and scope of this work cannot be more tersely or more accurately conveyed than by quoting *in extenso* the "compiler's preface."

"The object of this volume is to give in a condensed form the general principles of Mr. Herbert Spencer's Philosophy as far as possible in his original words. In order to carry out this intention each section (§) has been reduced, with but few exceptions, to one-tenth; the five thousand and more pages of the original being thus represented by a little over five hundred. The Epitome consequently represents 'The Synthetic Philosophy' as it would be seen through a diminishing glass: the original proportion holding between all its varied parts.

"Should this volume lead the general reader to a better acquaintance with Mr. Spencer's own works, I shall feel amply repaid for my labour.

"My warmest thanks are due to Mr. Spencer for his invaluable preface; and also to Miss Beatrice Potter, and Mr. Henry R. Tedder, F.S.A., the able and accomplished secretary and librarian of the Athenæum Club, for their valuable suggestions while the work has been in progress."

The desirability of such an undertaking, supposing it to have been successfully accomplished, is both manifest and manifold. Mr. Spencer's works are so voluminous that it is impossible to acquire a knowledge of his system of philosophy as a whole without devoting to it an expenditure of time which is practically impossible for most men who are not specially engaged in philosophic studies. Moreover, even to a reader who is thus specially engaged, and who therefore desires fully to master this system, no small difficulty is experienced from the fact that hitherto there has not been so much as an index to guide his

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